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BREEDING DISTRIBUTION OF THE BLACK TURNSTONE

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ABSTRACT.—Eighty-five percent of the world population of Black Turnstones (*Arenaria melanocephala*) nest on the central Yukon-Kuskokwim Delta, Alaska, 65% concentrated in a narrow band of salt grass, graminoid, and dwarf shrub meadows within two km of the coast. An estimated 61,000 to 99,000 birds (95% CI), with a point estimate of 80,000 birds, breed on the central delta. About 15,000 others nest elsewhere in Alaska. Abundance varies among habitats and with distance from the coast. On the central delta, highest breeding densities occur in coastal salt grass meadows (1.11 ± 0.16 birds·ha^{-1}) and lowest densities occur on dwarf shrub mat tundra (0.04 ± 0.04 birds·ha^{-1}). Breeding densities in mixed graminoid and dwarf shrub meadows decline significantly with distance from the coast, decreasing abruptly from 0.75 ± 0.11 birds·ha^{-1} within the first two km to 0.09 ± 0.03 birds·ha^{-1} farther inland. Although salt grass meadows constitute only 5% of the coastal lowlands, they support 25% of the population. *Received 5 April 1991, accepted 6 Aug. 1991.*

The Black Turnstone (*Arenaria melanocephala*) is one of the most maritime of New World shorebirds. The entire world breeding population is restricted to coastal habitats of western Alaska, where the birds breed from early May to late July (Handel 1982) before moving to wintering areas along the Pacific Coast from southcentral Alaska to central Mexico (AOU 1983). Little has been reported about the details of distribution or abundance of Black Turnstones within their breeding range. During a study of turnstone breeding ecology (Handel 1982), we conducted aerial and ground surveys of the Yukon-Kuskokwim Delta, an area for which published breeding records were most numerous (Conover 1926, Brandt 1943, Walkinshaw 1950, Gabrielson and Lincoln 1959, Kessel et al. 1964, Harris 1966, Holmes and Black 1973). Here we present results of these surveys, summarize previously unpublished breeding records, and identify habitats most important for breeding.

STUDY AREA

The Yukon and Kuskokwim rivers in western Alaska form the largest delta complex in North America, encompassing 129,500 km^2 (Thorsteinson et al. 1989). The delta predominantly is a flat plain of wet and moist tundra dotted with innumerable thaw lakes and crossed by meandering rivers, many of them active tributaries or former channels of the Yukon River (Wahrhaftig 1965; Dupré 1978, 1988). Shorebird habitats generally occur in bands parallel to the coast, changing along a gradient of increasing elevation and decreasing moisture and salinity. The coastal lowlands (Fig. 1) progress inland through a mixture of graminoid and dwarf shrub meadows up to 30 km inland. Storm surges regularly inundate

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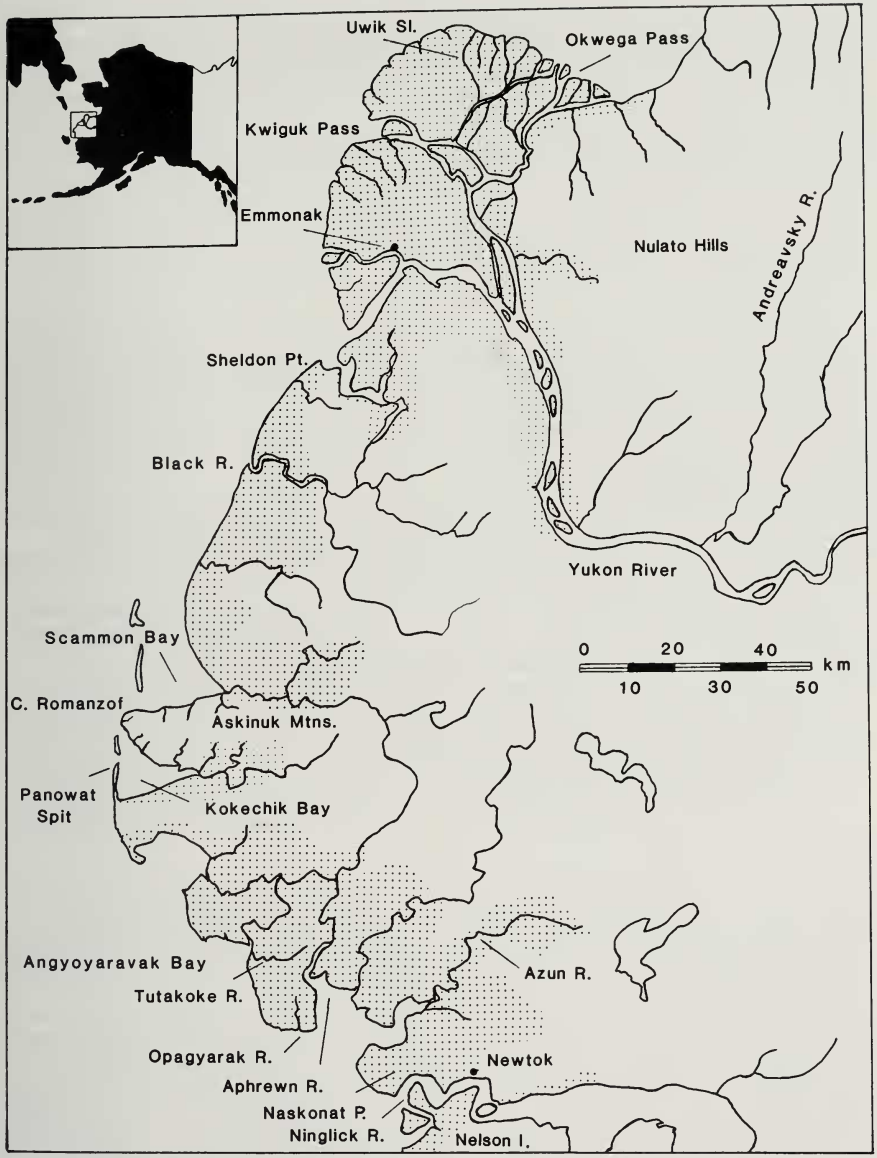

FIG. 1. The north and central Yukon-Kuskokwim Delta, Alaska, showing approximate extent of coastal lowlands (stippled area).

the coastal lowlands in late summer and fall (King and Dau 1981, Wise et al. 1981, Wise and Leslie 1988). Beyond are the uplands which are vegetated with dwarf shrub mat tundra not directly influenced by deltaic processes. On the active north delta, dwarf willows (*Salix* spp.) border coastal sloughs and tall thickets of willows and alders (*Alnus crispa*) occur farther inland (Jones and Kirchhoff 1977, Truett et al. 1984, Thorsteinson et al. 1989). Along the degrading, more tidally influenced central and southern portions of the delta, salt grass meadows dominated by *Carex ramenskii, Potentilla egedii,* and *Elymus arenarius* form "fingers" of habitat on eroding barren mudflats along the coast and at the mouths of major rivers. The central and southern parts of the delta are comparatively free of alder and willow thickets (Holmes and Black 1973, Jackson 1981, Tande and Jennings 1986).

METHODS

Museum searches.—We solicited data on egg sets and downy young of Black Turnstones from those museums listed by Kiff (1979) as having large oological holdings (see Acknowledgments). We used published and unpublished records to delineate the breeding range and to estimate relative abundance away from the Yukon-Kuskokwim Delta. A detailed summary of all breeding records is on file with the authors and with the University of Alaska Museum in Fairbanks.

Survey methods.—On 25 and 26 May 1978, we flew an aerial survey along 556 km of the Yukon-Kuskokwim Delta coastline from Okwega Pass south to Newtok, excluding a 97-km segment between Panowat Spit and the Tutakoke River (Fig. 1). We flew in a Cessna 185 on floats at an altitude of 60 m and a speed of 185 $km \cdot h^{-1}$. Two observers recorded all Black Turnstones within 100 m of each side of the aircraft as it flew parallel to and 200 m inland of the shoreline. One observer surveyed a second 100-m-wide aerial transect about 1 km inland of the shoreline from the Tutakoke River south to Newtok.

Between 30 May and 12 June 1981, we censused 25 randomly spaced ground transects perpendicular to the coast of Angyoyaravak Bay (Fig. 1). Transects were 30 m wide, averaged 3.1 ± 0.5 km in length (range 1.2–11.2 km), and were subdivided into 80-m long blocks. While walking parallel along the edges of each strip transect, two observers counted all turnstones flushing from or flying across each block. The predominant habitat within each block was classified as salt grass meadow, mixed graminoid and dwarf shrub meadow, or dwarf shrub mat tundra.

From 1978 to 1982, we monitored all nesting attempts on a 20-ha study plot in a mixed graminoid and dwarf shrub meadow along the coast of Angyoyaravak Bay (Handel 1982). Turnstones nesting on the study plot were captured and marked with unique combinations of colored leg bands. All nests on a second 20-ha plot in an adjacent salt grass meadow were monitored from 1978 to 1981 but no birds were color marked.

We used an electronic digitizing planimeter to measure the area of coastal lowland marshes and meadows between the Askinuk Mountains and the north side of Nelson Island (Fig. 1) as classified on 1:250,000 scale Landsat vegetation maps (Talbot et al. 1985). Since salt grass meadows were not discernible from this Landsat interpretation, their extent within 5 km of the coast was measured from color infrared aerial photographs (1:120,000 and 1:60,000) taken from 1970 to 1980 (U.S. Geological Survey, unpublished imagery).

Statistical analyses.—The distribution of turnstones within Angyoyaravak Bay was analyzed with respect to habitat type and distance from the coast. All 80-m blocks of the same predominant habitat within each transect were combined into single samples for comparison of densities. We used nonparametric procedures to test for differences among habitats and to measure linear relationships between densities and distance from the coast (Conover 1980). Statistical analyses were conducted using the SPSS (1990) software package, and differences were considered significant at the 0.05 level. Data are presented as mean ± standard error unless stated otherwise.

We stratified coastal lowlands before we estimated the size of the turnstone population nesting on the central Yukon-Kuskokwim Delta. Stratification was based on statistically significant differences among densities detected on ground transects in Angyoyaravak Bay in different habitats and at different distances from the coast. For each of the two study plots we then calculated the ratio between the known nesting density and the density detected on adjacent transects. We averaged these two ratios to obtain a correction factor ($\bar{c}$). The point estimate of the population total was obtained by the following formula: $T = \sum_{i=1}^{k} (\bar{d}_i \cdot \bar{c} \cdot a_i)$, where T = population total, k = number of strata, $\bar{d}_i$ = mean observed density in stratum i, $\bar{c}$ = mean correction factor for the two study plots, and a_i = area of stratum i.

To obtain confidence intervals for the population estimate, we calculated a bootstrap estimate for the standard error of the mean corrected-density for each stratum. First we randomly resampled (with replacement) the N original observed densities within each stratum for a bootstrap sample of size N. We then multiplied these by one of the two correction ratios (randomly selected) to obtain a bootstrap sample of N corrected-densities. This procedure was replicated for each stratum 100 times to estimate the distribution function and calculate the standard error of the mean corrected-density within each stratum. Using these standard errors, we calculated 95% confidence intervals for the population estimate within each stratum. Finally, we calculated the estimated variance and 95% confidence limits for the stratified population total: $95\%\ CI = T \pm 1.96 \cdot (\sum_{i=1}^{k} a_i^2[s_i^2])^{0.5}$, where T = population total, k = number of strata, a_i = area of stratum i, and s_i = standard error of the mean corrected-density in stratum i.

This population estimate was based on three assumptions: (1) that the densities detected on ground transects in Angyoyaravak Bay were a representative sample of those in other bays on the central delta; (2) that the densities detected on ground transects within 12 km of the coast were representative samples of those occurring up to 25 km inland within the same strata; and (3) that the correction factors calculated for the two study plots represented a random sample of such correction factors for other breeding areas sampled.

RESULTS

General breeding distribution and habitat.—We found 254 records of nests, egg sets, or downy young of Black Turnstones from 33 different locations in Alaska, including 15 previously unpublished sites (Table 1, Fig. 2). Most (60%) of the records, including three new nesting records from north Nelson Island, were from five coastal breeding areas on the central Yukon-Kuskokwim Delta in salt grass meadows and mixed graminoid and dwarf shrub meadows. South of the central delta, breeding records were found for seven new sites with similar habitats, including south Nelson Island, Kegaktuk Island just off Nunivak Island, and various sites along the Kuskokwim River as far inland as Bethel.

To the north, breeding was recorded for four new sites on the north Yukon Delta, two new sites on the Seward Peninsula, and one new site on the North Slope. Four of five nests found on the Yukon River for which habitat was recorded were situated on a small island and surrounded by willow stems; the fifth was on a narrow ridge of mossy tundra next to

TABLE 1
PREVIOUSLY UNPUBLISHED BREEDING LOCATIONS OF THE BLACK TURNSTONE

Region and site	Year	Record type	Collector or observer
North Slope			
Utukok River	1978–1982[a]	1 nest	J. Hechtel, pers. comm.
Seward Peninsula			
Kalik River	1991	1+ downy young	M. Stishov, pers. comm.
Arctic Lagoon	1991	1+ downy young	M. Stishov, pers. comm.
North Yukon Delta			
St. Michael	Unknown	1 egg set	C. L. Hall
"Mouth of Yukon"	1898	2 egg sets	J. H. Spencer
Kwikpak Pass, Yukon Rv.	1929	1 egg set	S. Warburton
Kwiguk, Yukon Rv.	1929	4 egg sets	S. Warburton
Central Yukon-Kuskokwim Delta			
N. Nelson Island	1910	1 egg set	J. Koren
N. Nelson Island	1967	2 nests	J. Hout, unpubl.
South Yukon-Kuskokwim Delta			
S. Nelson Island	1984	4 nests	R. Stehn, pers. comm.
Nunivak Island	1983	1 downy young	G. V. Byrd, W. Butler, pers. comm.
Kipnuk	1954–1955	3 egg sets	W. M. Batterson
"Near Quigillingok"	1930	3 egg sets	D. B. Bull
Kuskokwim Delta	1931	4 egg sets	D. B. Bull
Quinhagak	1934	3 egg sets	A. Johnson, "Native"
Bethel	1929–1930	2 egg sets	D. B. Bull

[a] Turnstones observed all five years; exact date of nest unknown.

a wet meadow (S. Warburton, unpubl. egg specimen records). On the Seward Peninsula, M. Stishov (pers. comm.) recorded 57 adults and several unfledged young on 3–4 July 1991 in salt grass and graminoid meadows along the inner beach of the Arctic Lagoon barrier spit. On 5–6 July 1991 he also recorded 52 adult Black Turnstones and several unfledged young in similar meadows along the Kalik River up to 2–3 km from the mouth. The most northern breeding record was that of a nest on the Utukok River in the Brooks Range. The nest was under a willow shrub on a gravel bar about 7 km below the confluence with Driftwood Creek (J. Hechtel, pers. comm.). Hechtel considered the species "common" along several kilometers of the river each summer he worked there (1978–1982). Identity was confirmed by D. D. Gibson (pers. comm.) from photographs of adults in the area.

FIG. 2. Locations of previously published (solid circles) and unpublished (open circles) breeding records of Black Turnstones. Questionable published breeding records are indicated by solid triangles.

Distribution along the Yukon-Kuskokwim Delta coast.—On aerial surveys in spring 1978, no turnstones were encountered along 135 km of coastline of the north Yukon Delta between Okwega Pass and Sheldon Point (Table 2). A single turnstone was sighted, however, on mudflats of an exposed bar in Kwiguk Pass, 17 km inland, when the plane landed for refueling at Emmonak (Fig. 1). Low numbers were encountered south along the coast between Sheldon Point and Scammon Bay (0.01 birds·ha^{-1}). Most of these were just south of the Black River. No turnstones were seen along the predominantly rocky coast around Cape Romanzof or along the sandy Panowat Spit (Fig. 1). Highest densities (0.17 birds·ha^{-1}) were detected along the coast of the central delta between Kokechik Bay and the Ninglick River (Table 2). The largest concentrations there occurred between the Opagyarak and Aphrewn rivers (0.32 birds·ha^{-1}) and on the Naskonat Peninsula (0.26 birds·ha^{-1}), although the coast between Panowat Spit and the Tutakoke River, including Angyoyaravak

TABLE 2

NUMBERS AND RELATIVE DENSITIES OF BLACK TURNSTONES OBSERVED DURING AERIAL SURVEYS ALONG COASTAL TUNDRA AND 1 KM INLAND ON THE YUKON-KUSKOKWIM DELTA, ALASKA, ON 25–26 MAY 1978

Area surveyed	Length of coast (km)	No. birds	No. birds·ha^{-1}
Along coast[a]			
North delta	135	0	0
Black River area	109	30	0.01
Central delta	150	499	0.17
One km inland[b]			
Central delta	128	67	0.05

[a] Strip transects along coast were 200 m wide. North delta = Okwega Pass–Sheldon Point; Black River area = Sheldon Point–Scammon Bay; central delta = Kokechik Bay–Newtok, excluding 55 km around Cape Romanzof and 10 km along Panowat Spit, where there were no turnstones, and 97 km between Panowat Spit and the Tutakoke River, which was not surveyed (Fig. 1).

[b] Strip transects 1 km inland were 100 m wide. Survey area = Tutakoke River–Newtok (Fig. 1).

Bay, was not surveyed. Densities 1 km inland were only about a third of those along the immediate coast (Table 2).

Distribution in relation to habitat and distance from coast.—The abundance of turnstones on ground transects surrounding Angyoyaravak Bay varied with habitat and with distance from the coast (Fig. 3). Highest densities were found in salt grass meadows with a significant peak at 3–4 km inland ($P = 0.045$, Kruskal-Wallis test), although sample sizes of salt grass habitat beyond 2 km from the coast were limited. Among 10 transects that included some salt grass meadows, overall detections averaged 2.83 ± 0.40 birds·ha^{-1}.

Intermediate densities occurred in mixed graminoid and dwarf shrub meadows (Fig. 3). In this habitat, bird abundance declined abruptly between 0 and 3 km from the coast ($P = 0.014$, $r_s = -0.41$) and more gradually farther inland ($P = 0.013$, $r_s = -0.32$). Turnstones were scarce (0.10 ± 0.10 birds·ha^{-1}, $N = 7$) on dwarf shrub mat tundra, which occurred predominantly inland. Combining all habitats except salt grass meadows, detection rates averaged 1.91 ± 0.30 birds·ha^{-1} ($N = 12$) within 2 km of the coast and fell to 0.23 ± 0.06 birds·ha^{-1} ($N = 13$) farther inland.

Estimate of true nesting densities.—Between 1978 and 1982, nesting densities averaged 0.95 ± 0.10 pairs·ha^{-1} in mixed graminoid and dwarf shrub meadow and 1.18 ± 0.15 pairs·ha^{-1} in salt grass meadow on the two study plots at the mouth of the Tutakoke River (Table 3). Densities were higher on salt grass meadow in every year except 1979.

During 1981, 4.34 ± 0.81 birds·ha^{-1} were detected on four transects near the first study plot, and 5.73 ± 0.52 birds·ha^{-1} were detected on

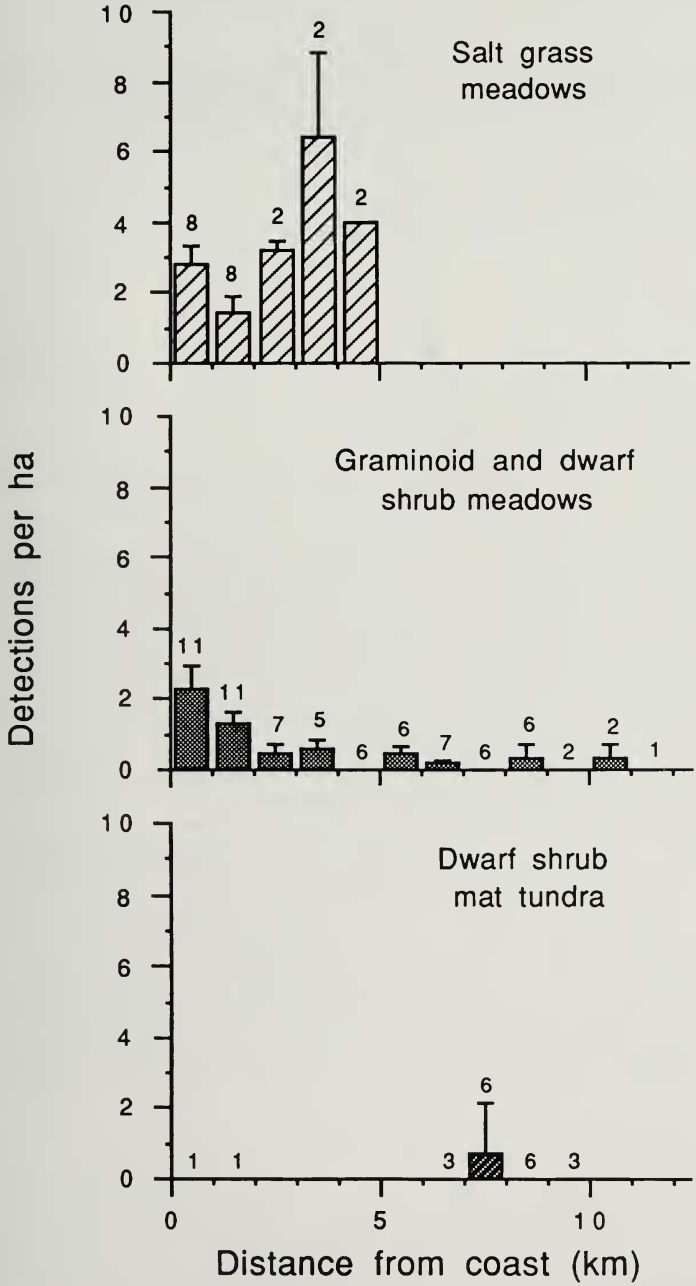

FIG. 3. Number of Black Turnstones detected per hectare during ground surveys in Angyoyaravak Bay, shown by habitat and distance from the coast. Data are shown as $\bar{x} \pm$ SE. The number of transects is indicated above each bar.

TABLE 3

NUMBER OF NESTS (EXCLUDING KNOWN OR SUSPECTED RENESTS) AND DENSITIES OF NESTING PAIRS OF BLACK TURNSTONES ON TWO 20-HA STUDY PLOTS IN DIFFERENT HABITATS AT THE MOUTH OF THE TUTAKOKE RIVER, ALASKA

	Graminoid and dwarf shrub meadow		Salt grass meadow	
Year	No. nests	Pairs·ha^{-1}	No. nests	Pairs·ha^{-1}
1978	18	0.90	29	1.45
1979	26	1.30	15	0.75
1980	21	1.05	25	1.25
1981	15	0.75	25	1.25
1982	15	0.75	—[a]	—[a]
$\bar{x} \pm$ SE	19 ± 2	0.95 ± 0.10	24 ± 3	1.18 ± 0.15

[a] Plot in salt grass meadow was not censused in 1982.

two transects near the second plot. The ratio between known nesting densities on the plots and those detected on nearby transects was 0.346 and 0.436 for the two plots, respectively. The mean correction factor was 0.391 nesting birds per detection. From this, we estimate that turnstones nested in coastal salt grass meadows at a density of 1.11 ± 0.16 birds·ha^{-1}; in mixed graminoid and dwarf shrub meadows at 0.75 ± 0.11 birds·ha^{-1} within 2 km of the coast and at 0.09 ± 0.03 birds·ha^{-1} farther inland; and on dwarf shrub mat tundra at very low densities of 0.04 ± 0.04 birds·ha^{-1}. Because dwarf shrub mat tundra was scarce in our samples, the estimate of density did not change when this habitat was combined with graminoid and dwarf shrub meadows (Table 4).

Population estimate for the central Yukon-Kuskokwim Delta.—The population of Black Turnstones nesting on coastal lowlands between the Askinuk Mountains and north Nelson Island (Fig. 1) was estimated at 61,000 to 99,000 birds (95% CI) with a point estimate of about 80,000 birds (Table 4). Coastal salt grass meadows supported more than a quarter of the population. About 65% of the turnstones concentrated in salt grass meadows and other habitats within 2 km of the coast. The remainder were scattered at very low densities throughout interior lowlands (Table 4).

DISCUSSION

Distribution patterns.—Our surveys clearly demonstrated that the breeding distribution of Black Turnstones on the central Yukon-Kuskokwim Delta is closely linked to the distribution of salt grass meadows. This pattern is consistent with historical museum records and with earlier published accounts. The distribution of turnstones in coastal habitats

TABLE 4

ESTIMATE OF THE SIZE OF THE NESTING POPULATION OF BLACK TURNSTONES ON COASTAL LOWLANDS OF THE CENTRAL YUKON-KUSKOKWIM DELTA BETWEEN THE ASKINUK MOUNTAINS AND NORTH NELSON ISLAND

Habitat	Area (km^2)	Estimated nesting density ($birds \cdot ha^{-1}$)[a]	Population size	
			Point estimate	95% CI
Coastal salt grass meadows	190	1.11 ± 0.159	21,000	15,000–27,000
Other habitats				
0–2 km from coast	400	0.75 ± 0.106	30,000	22,000–38,000
>2 km from coast	3245	0.09 ± 0.025	29,000	13,000–45,000
Total	3835	0.21 ± 0.025	80,000	61,000–99,000

[a] Corrected mean = mean number detected on transects · mean correction factor (0.391) derived from study plots; standard error = estimate from 100 bootstrap samples in each stratum. See Methods for details.

within Angyoyaravak Bay also mirrored that found across the entire Yukon-Kuskokwim Delta during surveys in 1979 and 1981 of breeding birds present on a sample of 65-ha plots (Yukon Delta National Wildlife Refuge [YDNWR], unpubl. data). On these surveys, turnstones were recorded on 94% of 17 plots in salt grass, graminoid, and dwarf shrub meadows, on 60% of 10 plots vegetated about equally by meadows and dwarf shrub mat tundra, and on only 33% of nine plots in dwarf shrub mat tundra. The importance of salt grass meadows to the central delta population is emphasized by the fact that this habitat supports about 25% of the breeding population but comprises only 5% of the coastal lowlands. Elsewhere throughout their range, Black Turnstones appear to be almost entirely restricted to salt grass meadows (see Murie 1959, Williamson and Peyton 1962, Wright 1979, Gill et al. 1981, Kessel 1989, Petersen et al. 1991).

There are, however, some notable exceptions to this pattern. Sparsely vegetated islands and shorelines of low relief along major rivers are used more regularly for breeding than has been previously recognized. This conclusion is supported by the inland breeding records along various active tributaries of the Yukon River, on the Kuskokwim River near Bethel, throughout Bristol Bay, and on the Utukok River in the Brooks Range. Our sighting of a turnstone on the north Yukon Delta at Emmonak (Fig. 1), along with other records, suggests that they may breed in very low densities throughout the deltaic system. During a study of avian habitats at the mouth of Uwik Slough (Fig. 1), R. D. Jones, Jr. and M. Kirchhoff (unpubl. data) recorded adults six times during June and once in July 1977. They also observed several juveniles in late summer. During

a survey of the entire north delta in June and July of 1985, turnstones were recorded seven times at four different sites within 15 km of the coast (C. Ziobran, YDNWR, unpubl. data). Twelve turnstones were also encountered from 7–29 June 1985 along a 70-km stretch of the Andreavsky River up to 90 km inland in the adjacent Nulato Hills (E. Buelna, YDNWR, unpubl. data). A single bird was sighted on the east fork of the river on 16 June 1988 (B. J. McCaffery, YDNWR, in litt.).

The reported occurrence of a small breeding population of Black Turnstones far inland along the Utukok River (Table 1; J. Hechtel, pers. comm.) constitutes a northern extension of the species' known breeding range. Because of the remoteness of this region, we do not know if their occurrence constitutes a recent pioneering effort. There are no other records north of Kotzebue Sound, either inland in neighboring mountains (Childs 1969, Dean and Chesemore 1974) or along the coast (Bailey 1948, Gill et al. 1985, W. Lehnhausen and S. Quinlan, unpubl. data).

We question two previously published breeding records at the inland and southern distributional limits (Fig. 2). The most inland record, eggs collected at Takshagemut (=Takshak Village) about 155 km inland along the Yukon River in 1868 (Gabrielson and Lincoln 1959), is probably erroneous. Based on accounts of early expeditions to this area, including William Dall's (1970) journal, we believe that the single egg set collected on the Yukon River that year was only about 60 km from the mouth of the river. The southernmost record for Chichagof Island (Abbott 1915) remains somewhat of a mystery because we were unable to locate the original egg set or any written account of the expedition. No other breeding records for southeastern Alaska exist, and there is no habitat currently considered suitable for their nesting on Chichagof Island (Webster 1986, in litt.). We consider this area to be well out of the normal breeding range for the species.

Population estimate.—Based on the available data, we estimate that about 80,000 turnstones breed on the central delta between Kokechik Bay and north Nelson Island, but this estimate may be high. We are more confident in the estimate for coastal salt grass meadows (21,000) and less confident in the estimate of numbers dispersed over interior lowland (29,000). The latter is derived from fewer samples of a much greater area. With the limited data, we had to assume that densities detected from 2–12 km inland also occurred up to 25 km inland. Dwarf shrub mat tundra, which supports extremely low densities of nesting Black Turnstones, occurs in increasing abundance inland within the zone we delineated as coastal lowlands. Since we had no accurate measure of its abundance relative to the meadows with which it is interspersed, we were not able to treat this as a separate stratum to refine our population estimate.

Given the distribution of appropriate habitats and data gleaned from museum records and other studies, we speculate that no more than about 15,000 turnstones breed in Alaska away from the central Yukon-Kuskokwim Delta. The second greatest concentration of breeding Black Turnstones probably occurs on coastal lowlands between south Nelson Island and Goodnews Bay, surrounding the Kuskokwim River mouth (Fig. 2). Overall, the turnstone world breeding population probably numbers no more than 95,000 individuals, of which about two-thirds nest within 2 km of the coast.

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